REMARKS

Claims 1, 5-23, 25-30, and 32-45 remain in the application. The Applicant has cancelled claims 2-4, 24, and 31. The Examiner has indicated that claims 7-12, 21, 22, 36, and 37 would be allowable if rewritten in independent form including all base and intervening claim limitations.

The Office Action rejects claims 25 and 26 under 35 U.S.C. § 112 ¶ 2 as being indefinite. In response, the Applicant has canceled claims 25 and 26.

The Office Action rejects claims 1-6, 13-20, 23, 25-35, 38-43, and 45 under 35 U.S.C. § 102(e) as being anticipated by Carl et al. (US6047216).

As defined in the amended claim 1, the subject invention comprises an elongate microwave radiator for insertion into a living body to treat biological tissue at a predetermined operating frequency. The claim limits the radiator to comprise a monopole at its tip and dielectric material surrounding the monopole. As amended, claim 1 describes the dielectric material as being configured to act as a resonator at the predetermined operating frequency and to encompass generally the whole of the near-field radiation emitted by the monopole. Similarly, as defined in amended claim 45, the subject invention includes an elongate microwave radiator for insertion into a living body to treat biological material at a predetermined operating frequency. As with claim 1, claim 45 limits the radiator to comprise a monopole and dielectric material surrounding the monopole. The length of the monopole and the dielectric constant and dimensions of the dielectric material relative to the monopole are selected in relation to the predetermined operating frequency of the applicator such that the dielectric material acts as a resonator at the predetermined operating frequency and the dielectric material also encompasses generally the whole of the near-field radiation emitted by the monopole.

The Applicant has amended claims 1 and 45 to recite that the dielectric material, in addition to encompassing generally the whole of the near-field radiation emitted by the monopole, is configured to act as a resonator at the predetermined operating frequency. This resonant feature of the radiator is disclosed in the application (WO00/440057) on page 2, paragraph 3, and page 5, paragraph 1. The third paragraph of page 2 reads as follows:

> The length L of the antenna may be substantially equal to half a wavelength, in which case the radius of the cylindrical dielectric body is substantially equal to half a wavelength. The antenna is then tuned to act as a resonator, which increases the power it radiates.

If the term "antenna" is properly understood to refer to the whole of the monopole antenna assembly including the dielectric, then it will be understood that the dielectric itself is sized to act as a resonator by virtue of its radius of half a wavelength. This understanding is confirmed on page 3 of the application where there is the further statement:

> Advantageously, the dielectric body is tuned to act as a resonator to further enhance radiation from the tip of the elongate device in the insertion direction. In particular, the diameter of the dielectric body is substantially equal to the wavelength of the radiation, and the tip portion is substantially hemispherical and has a radius substantially equal to half a wavelength of the radiation.

This description in relation to the embodiment of Figure 2, makes it clear that the dielectric body is tuned to act as a resonator by virtue of its diameter being substantially equal to the wavelength of the radiation. This is the same requirement that applies to the embodiment of Figure 5, which also has a dielectric body with a diameter of a wavelength, as stated in the quoted passage on page 2, and confirmed on page 6, which described the radius of the dielectric body 350 as substantially equal to half a wavelength.

The difference between the embodiments of Figure 2 and Figure 5 is that the tip of the device in Figure 2 is hemispherical so as to enhance forwards transmission of radiation, whereas the tip of the device in Figure 5 is pointed to assist penetration into biological material. The forwards transmission of radiation is enhanced by the hemispherical shape and its radius equal to half a wavelength, which serves to make the tip portion resonant. This fact is described in the quoted passage on page 3 and the description of Figure 2 on page 5, which states that:

> In order to enhance radiation from the antenna in the forward direction, the dielectric body 250, in addition to comprising a cylindrical portion 260 which envelops the exposed length of core conductor 240, comprises a hemispherical section 270 which supports partial internal reflection of the radiation from the antenna in the forward direction and indicated by arrows 280 and 290. Preferably, the hemispherical section 270 is dimensioned so as to provide a resonator which further enhances radiation from the dielectric body 250 in the forward direction.

It's clear from the last sentence that the design parameters in relation to the embodiments of Figures 2 and 5 are generally the same except that the hemispherical tip of the embodiment of Figure 2 is designed to resonate and to enhance forwards transmission of radiation. This is not the case with the embodiment of Figure 5 with the pointed tip, but in every other way its design is the same as that of Figure 2.

Accordingly, the Applicant submits that a skilled person in the art would clearly understand that the statement on page 2, that "[t]he antenna is then tuned to act as a resonator" means that the complete assembly of the monopole and dielectric body is tuned to act as a resonator, and that it is the radius of the dielectric body being equal to half a wavelength, which makes it resonant.

The Applicant has also amended the claims to include the term "monopole" in place of the term "antenna" to more accurately describe the claimed structure in question. The drawings and specification clearly describe a structure that meets the definition of a monopole antenna as set forth in the attached page extracted from a text book on the subject. The definition set forth in this text book extract is associated with a representation of a monopole antenna in Figure 2.11 that is quite similar to the representations of Figure 2 and 5 of the present application. The central conductor shown at 240 in Figure 2 and at 340 in Figure 5 extends beyond the outer screening 210 in Figure 2 and in Figure 5 (no reference numeral for the outer screening in Figure 5). The outer screening forms a ground plane so that the exposed conductor forms a monopole. Rather than showing a quarter wave monopole as depicted in the text extract, the present application discloses is a half wave monopole. The normal radial pattern of radiation from a monopole is also clearly shown in Figure 2.12 of the text book extract. Another point to note from the text book definition is that the overall assembly is referred to as a monopole antenna, and the exposed conductor itself is referred to as a monopole. For reasons of clarity, the Applicant has amended the claims and application to conform to this terminology convention and maintains that one of ordinary skill in the art would understand that the term "antenna" refers to the whole of the monopole antenna assembly including the dielectric body, and not only the monopole.

The fact that the dielectric body is an essential active component of the antenna is made clear in different passages that describe the effect of the body in reducing the wavelength of the radiation within it. For example, see the paragraph at the top of page 2 of the specification of the published PCT application. A skilled person in the art would be familiar with comparable antenna systems comprising a dipole supplemented by other active components to ensure that the antenna operates in the required manner. For example, a satellite TV antenna including a parabolic dish as an additional element, and a terrestrial TV antenna in the form of a yagi array have additional multiple parasitic dipoles attached to the driven dipole. In each case, the whole system is referred to as the antenna, rather than just the dipole.

As amended, claims 1 and 45 now specify two significant limitations related to the dielectric material, namely:

> 1. The dielectric material acts as a resonator, and
>
> 2. The dielectric material encompasses generally the whole of the near-field radiation at the predetermined operating frequency.

Regarding the first limitation, the Applicant notes that the dielectric material of such a microwave radiator will be resonant if its diameter is equal to half a wavelength or a multiple of half a wavelength (although this dimension may be relaxed slightly without losing the resonant condition). Carl et al. (US6047216) neither disclose nor suggest adapting dielectric material to act as a resonator. Instead, Carl et al. disclose a microwave radiator comprising a monopole antenna embedded in a dielectric material (Teflon) specified to have diameters on the order of 2mm, and operating frequencies ranging from 1Ghz to 25 or 30Ghz. Consequently, the minimum wavelength in the Teflon material would be 69mm, which is far greater than twice the diameter of the dielectric material. Consequently, one would not expect the radiator in Carl et al. to be resonant.

The second limitation related to the dielectric material, i.e., that the dielectric material encompasses generally the whole of the near-field radiation from the monopole, can be assessed using the formula $2L^2/\lambda$ where L is the length of the monopole. As L increases, the near-field extends further from the monopole. As L decreases, the near-field recedes. In addition, as L decreases below $\lambda/4$, the amount of radiated power falls to an insignificant level. L therefore has a minimum acceptable value and an optimum value of $\lambda/2$. This optimum value is associated with impedance matching of the antenna as is well known in the art to those familiar with the radiating properties of monopole antennas. Using this optimum value in the above formula, the near-field radiation can be shown to extend radially a distance of $\lambda/2$ from the monopole, which equals the radial dimension of the dielectric material required to make it a resonator. The two significant limitations related to dielectric material

in claim 1 are therefore complementary, and both improve the performance of a microwave radiator constructed according to the invention.

Carl et al. neither disclose nor suggest any feature that satisfies either of these limitations. More specifically, while Carl et al. disclose a radiator including a monopole antenna in Figure 3, and disclose in column 16 that the length of the antenna is related to the device operating frequency, Carl et al. do not disclose dimensions. While it may be possible to deduce that several combinations of parameters over the lower end of the frequency range can generate a near-field within the 2mm diameter, the wavelength in the Teflon will generally be much greater than the length of the antenna. The antenna will not therefore operate as an effective radiator and will be considerably longer than the optimum length of $\lambda/2$.

In the "Response to Arguments" the Office Action cites certain disclosure from Carl et al. as meeting the limitations of, e.g., claims 1 and 45. In so doing, the Office Action assumes a monopole antenna device as illustrated in Figure 3, assumes a diameter of 2.76mm as is ostensibly shown in Figure 10, and an operating frequency between 2Ghz and 300Ghz. The Examiner uses the equation $c=f \times\lambda$ to calculate corresponding wavelengths in the range of 0.476mm to 71.4mm at these operating frequencies. The Applicant asks that the Examiner review these results, however, since the Applicant's results are somewhat different: at 1Ghz, in air, the Applicant's calculations show that the wavelength of the radiation will equal 300mm. In Teflon, the wavelength is reduced to about 214mm. Since all other wavelengths are proportional to frequency under the same conditions, a frequency of 2Ghz is associated with a wavelength of 107mm, a frequency of 30Ghz is associated with a wavelength of about 7mm, and a frequency of 300Ghz is associated with a wavelength of about 0.7mm. In addition, the Applicant notes that there is no reference in Carl et al. of a top frequency value of 300Ghz with regards to the embodiment of Figure 3. Instead, Carl et al., in column 6, disclose an operating frequency range of 2Ghz to 25 or 30Ghz for that embodiment. The 300 GHz value is disclosed only in relation to the embodiment of Figure 2 and is not preferred for use with the antenna of Figure 3.

In the "Response to Arguments" section the Office action makes assumptions about whether and the extent to which the near-field radiation of the Carl et al. radiator may be limited to within a diameter of 2.76mm. However, as the Applicant has previously argued, this comparison is only possible if one assumes some value for the antenna length L. The Examiner has obtained a value for L by taking notional measurements off of Figure 3 by scaling the length referenced 322 to the assumed diameter of 2.76mm. According to this method, the value of L is 6.4mm. Using this value for L in the equation $R=2L^2/\lambda$, the following table shows corresponding values relating to the extent of the near field at four different frequencies ranging from 2Ghz to 300Ghz:

	2Ghz	3.5Ghz	30Ghz	300Ghz
Wavelength	103.5mm	59.4mm	7.0mm	0.7mm
R =	0.79mm	1.38mm	11.7mm	117mm
L =	6% of λ	11% of λ	91% of λ	910% of λ
D =	2.6% of λ	4.6% of λ	39% of λ	390% of λ

It can be seen from the above figures that the extent of the near-field radiation R starts to reduce within the Teflon (radius 1.38mm) at frequencies of 3.5Ghz and below. However, the percentage values for the length L of the antenna and the diameter D of the dielectric relative to the wavelength demonstrates that these values are both well below half a wavelength and even a quarter of a wavelength. The significance of this in the context of the invention is that the relatively short antenna length of 6.4mm will prevent the antenna from being an effective energy radiator. Furthermore, the relatively small diameter of the dielectric material will preclude the dielectric material from operating as a resonator. These two conditions, together with the requirement that the dielectric encompass the near-field, specify an improved microwave radiator that is neither taught nor suggested in the prior art. In other words, one cannot arrive at the invention by merely choosing parameters within known ranges as disclosed in the prior art. The critical difference is that, according to the invention, the dielectric must be configured to have a high enough dielectric constant to both reduce the wavelength within the dielectric and to allow the matching of the various dimensions, as explained above.

For these reasons, the Applicant maintains that Carl et al. do not anticipate either amended claim 1 or amended claim 45, and that there is no suggestion in the prior art of record or in knowledge generally available to those of ordinary skill in the art to modify the Carl et al. radiator to meet the limitations of either of these claims.

As defined in the amended claim 23 (directed to the embodiment of Figures 2 and 3), the subject invention includes an elongate radiator for insertion into a living body to treat biological tissue at a predetermined operating frequency. The radiator comprises a monopole at its tip and dielectric material surrounding and extending beyond the monopole. The dielectric material terminates in a rounded tip portion and is configured to act as a resonator at said predetermined operating frequency to enhance transmission of radiation in the forward direction. As with claim 1, the Applicant has amended claim 23 to describe the dielectric material as being adapted to act as a resonator at the predetermined operating frequency. This feature, together with the rounded tip, serves to enhance the transmission of radiation in the forward direction. As already explained above, Carl et al. do not disclose this feature of the dielectric resonator. For this reason the Applicant maintains that the Carl et al. patent does not anticipate claim 23, and that there is no suggestion in the prior art of record or in knowledge generally available to those of ordinary skill in the art to modify the Carl et al. radiator to meet the limitations of claim 23.

As defined in amended claim 30, the subject invention includes a method of coupling radiation into biological material, the radiation being generated by an applicator comprising a monopole surrounded by a dielectric body, comprising the steps of configuring the dielectric body to act as a resonator and selecting the dielectric constant of the body in accordance with the wavelength of the radiation in the dielectric so that generally the whole of the near-field of the radiation is encompassed by the dielectric body. Similar to claim 30, as defined in amended claim 38, the subject invention includes a method of coupling radiation into biological material. The method includes the step of providing an elongate applicator comprising a monopole surrounded by a dielectric body configured to extend axially of, and beyond the end of the monopole and to terminate in a rounded end portion that has a progressively reducing cross section along the axis away from the monopole. The method further includes the steps of causing the dielectric body to act as a resonator at the predetermined operating frequency, and transmitting radiation from the rounded end. As explained above, the Carl et al. patent does not disclose a method of coupling radiation into biological material where the method includes configuring a dielectric body to act as a resonator. For this reason the Applicant maintains that the Carl et al. patent doesn't anticipate either claim 30 or claim 38, and that there is no suggestion in the prior art of record or in knowledge generally available to those of ordinary skill in the art to modify the Carl et al. radiator to meet the limitations of either of those claims.

The Office Action rejects claim 44 under 35 U.S.C. 102(b) as being anticipated by Kasevich et al. (US6097985). According to the action, Kasevich discloses a radiator meeting all the limitations of claim 44.

The invention as recited in claim 44 involves an integrated component in the form of a radiator with a pointed tip, which is intended to be inserted directly into a liver to treat a tumour. In contrast, the catheter 203 in Kasevich is not intended to penetrate biological material, but is rather intended to be inserted into the body through existing body passages. In fact, the inflatable nature of the balloon body 203 teaches away from the penetration of biological material since it would not be consistent with the natural requirement for a body to be rigid to pierce and penetrate biological material. To emphasize the fact that the tip penetrates the liver, the applicant has further amended claim 44 to include this

limitation as an additional step in claim 44. Text supporting this addition can be found on page 2, paragraph 2, of the corresponding International application (WO00/449957).

The Applicant has additionally amended claim 44 to emphasize that the pointed tip is formed at the end of the elongated body that radiates the microwaves. In Kasevich, the antenna 200 illustrated in Figure 5 has a dipole 207 that transmits the microwaves. However, the dipole is not formed with a pointed tip. According to the Office Action, a pointed tip is formed at the end of the catheter 203 into which the antenna 200 is inserted. The catheter necessarily has a larger diameter than the antenna and the two serve different functions.

For these reasons the Applicant maintains that Kasevich et al. do not anticipate the amended claim 44.

Claims 1, 5-23, 25-30, and 32-45 recite patentable subject matter and are allowable. Therefore, the Applicant respectfully submits that the application is now in condition for allowance and respectfully solicits such allowance. Please favorably reconsider the outstanding Office Action.

I authorize the Commissioner to change any deficiencies, or credit any overpayment associated with this communication, to Deposit Account No. 59-0852. A duplicate copy of this sheet is enclosed.

Respectfully submitted,

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